PB81-158743

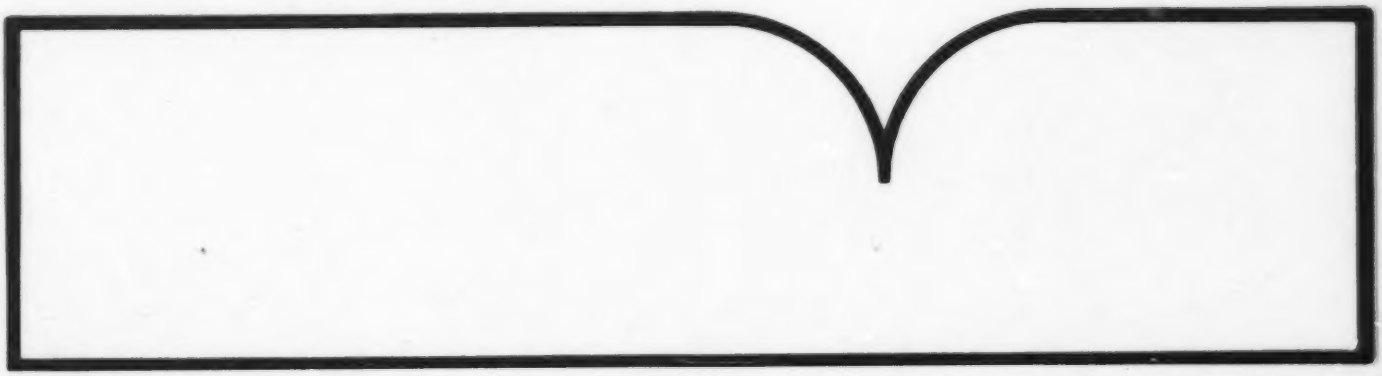
Cancer Mortality and Public Drinking Water in St. Louis City and County

Missouri Univ.-Columbia

Prepared for

Health Effects Research Lab.
Cincinnati, OH

Nov 80



U.S. Department of Commerce
National Technical Information Service
NTIS

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1. REPORT NO. EPA-600/J-80-203	2. JOURNAL ARTICLE
3. RECIPIENT'S ACCESSION NO. PB81 158743	
4. TITLE AND SUBTITLE: Cancer Mortality and Public Drinking Water in St. Louis City and County	5. REPORT DATE
	6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S): Carl J. Marienfeld et al. Univ. of Missouri	8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Univ. of Missouri Columbia, Mo.	10. PROGRAM ELEMENT NO.
	11. CONTRACT/GRANT NO. R805297
12. SPONSORING AGENCY NAME AND ADDRESS: U.S. EPA HERL Cincinnati, Ohio 45268	13. TYPE OF REPORT AND PERIOD COVERED
	14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES

Published: J. AWWA 72 #11:649-54 (Nov. 1980)

16. ABSTRACT

The results of recent studies do not appear to implicate drinking water as a major factor in producing the considerably higher cancer mortality rates in the city of St. Louis than in St. Louis County, pointing instead to such socioeconomic factors as low income, low educational level, and occupation as a laborer and to air pollution.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group

18. DISTRIBUTION STATEMENT: Release to Public	19. SECURITY CLASS *(This Report)* Unclassified	21. NO. OF PAGES
	20. SECURITY CLASS *(This page)* Unclassified	22. PRICE

EPA Form 2220-1 (Rev. 4-77) PREVIOUS EDITION IS OBSOLETE

PB81-158743

EPA-600/J-80-203
JOURNAL ARTICLE

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U. S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

Cancer mortality and public drinking water in St. Louis city and county

Carl J. Marienfeld, Michael D. Collins, Harley T. Wright, Ravula Reddy, Gary Shoop, Kay K. Roberts, and Philip Rust

The results of recent studies do not appear to implicate drinking water as a major factor in producing the considerably higher cancer mortality rates in the city of St. Louis than in St. Louis County, pointing instead to such socioeconomic factors as low income, low educational level, and occupation as a laborer and to air pollution.

The overall cancer mortality rates in New Orleans Parish have been known to be among the highest in the country.[1,2] The 1974 and 1976 studies by Harris et al[3,4] sought associations between the high cancer death rates and local environmental factors. The association of some cancer death rates among white males with drinking water supplies was found to be quite strong in New Orleans when compared to other Louisiana parishes that did not consume Mississippi River water. Carcinogens have also been identified in both raw and finished drinking water supplies derived from the Mississippi River.[5,6]

As in all such epidemiologic studies, an association between two variables, in this case cancer deaths and Mississippi River drinking water, does not assure that a cause-effect relationship has been established. Nevertheless, the study has had a salutary effect in bringing about a remarkable increase in research on chemical carcinogenesis. It has aided in producing drinking water legislation and a reevaluation of long-held beliefs in regard to the water disposal of wastes, of the safety of using dilution as the answer to pollution, and of the present methods of treating surface water. Current widely used practices such as sedimentation, chlorination, and sand filtration were designed primarily to render water bacteriologically safe for drinking and esthetically acceptable, and not to eliminate possible chemical carcinogens.

Study background

The New Orleans study revealed a number of epidemiologic inconsistencies in the postulated association between carcinogens in drinking water and high cancer death rates in the city that were difficult to explain.[7,8] Among these was the fact that the cancer death rates were not found to be excessively high among white females, who would have been expected to have been exposed to the same carcinogens. It has never been shown, in this regard, that females are apt to drink less water than do males. In fact, US cultural patterns, even during the past few decades, would suggest that

the usually more homebound female would consume more water than the male and therefore be at greater risk of exposure.

Secondly, death caused by lung cancer among New Orleans males made up a very large proportion of the higher than normal occurrence of cancer deaths, as is the case in most urban areas. It is difficult to implicate drinking water as a major cause of pulmonary cancer, particularly in an area like New Orleans where major air-polluting industries such as petroleum refining and chemical manufacture are located. These occupations generally engage a considerable number of males, who are thus subject to workplace exposure.

Disregarding these considerations, two mechanisms for carcinogenic chemical contamination of the Mississippi River at New Orleans were postulated.

First, the local area could be contaminated by chemical discharges at the point of or slightly upstream of the water plant intake, primarily from the numerous chemical and petroleum industries located in the area. It would be extremely difficult to separate direct air pollution from the workplace effects of these same industries, particularly since the greatest cancer mortality was found in lung cancer, which is more likely to be related to polluted air. This was made the more difficult by the investigator's statement that "data on air pollution by parish were unavailable," and that "occupational effect could exist but be buried in the data."[9]

The second or alternative explanation would be a possible increasing accumulation of carcinogens originating through waste discharges along the entire length of the river basin. These would then reach their maximum total accumulation at the bottom of the "Mississippi funnel" at New Orleans. The very great dilution brought about by the same tributaries that might be bringing in the discharged chemicals would seem to effectively refute this explanation and suggest an actual decrease in the concentration of the chemicals. Any increased carcinogenic effect would then appear to require some means of alteration or concentration of the well-diluted chemicals discharged upstream, either by some biological mechanism within the river or as an undesirable side effect of the water treatment methods being used.

Despite the unlikely possibility of such an increasing downstream carcinogenic chemical concentration, the Environmental Health Surveillance Center of the University of Missouri conducted a study to determine the possible corollary presence of a downstream increasing cancer mortality gradient.[3] This survey relied on data derived from the Missouri Public Drinking Water Census (1973)[8] and the US Census of Municipal Water Supplies (1964).[10] Counties were studied that used both the Missouri and Mississippi river waters on and within the borders of the state of Missouri as well as other counties in other states along both rivers, from their sources in Montana and Minnesota to New Orleans. Counties deriving more than 70 percent of their drinking water from the rivers and control counties using other water supplies were examined for all types of cancer and specific cancer mortality rates using the National Cancer Institute's report on cancer mortality by county (1950–1969).[2] No increasing downstream mortality gradient was detected in either the state of Missouri or within the total water basins. In fact, what appeared to be a random distribution of the high and low cancer mortality rates was found.[11] The New Orleans Mississippi funnel hypothesis could therefore not be supported.

The most interesting finding was that two of the midbasin water supply areas (the city of St. Louis and St. Louis County), both of which derived their water from the Missouri River within a short distance of each other, showed remarkable differences in cancer mortality rates. St. Louis had very high cancer mortality rates approaching those of New Orleans; St. Louis County, which encircles the independent city of St. Louis, showed very low rates for all cancers as well as for specific cancers.

This appeared to represent a "natural experiment." The study reported here was designed to determine whether the fact that these two communities shared a common source of water would incriminate or absolve the drinking water source as a factor of major importance among the many possible environmental cancer-associated variables in these communities. St. Louis is a central, highly industrialized city; St. Louis County is a suburban, primarily residential area that surrounds the major city on three sides.

The independent variable: public drinking water

The first factor to be considered was the water supply. St. Louis and St. Louis County both derive more than 70 percent of their population's drinking water from the Missouri River, but several potential differences in the water source exist.

St. Louis was classified as using only Missouri River water, but one of its two water plants was located on the Mississippi River just downstream of the Mississippi and Missouri River junction above the city. It was determined[12] by a laminar flow study of the Missouri River at the point of the plant intake on the western shore or Missouri side of the joined rivers that it was indeed Missouri River water and not upstream Mississippi River water that was being used as the drinking water source, just as it was at the other St. Louis city water plant located directly on the Missouri River.

Effect of alternate sources of supply. The other water supply factor of concern, in view of the marked difference in the cancer mortality rates in St. Louis and St. Louis County, was the possible rate-lowering effect of the approximately 20 percent of St. Louis County residents who used the Meramec River as their drinking water source. It was possible that a much lower mortality rate among the Meramec River water users could perhaps significantly lower the total St. Louis County rate. In addition, one community of fewer than 50 000, Kirkwood, was served by a deep well as well as by some water furnished by the St. Louis County Water Company.

To address these questions it was necessary to obtain, through the cooperation of the St. Louis County Water Company, the geographic location of the population within St. Louis County that had been served exclusively by Meramec River water since 1955 when this source became available.

The geographic boundaries between the Missouri and Meramec water users were found to be quite definite, and it was therefore possible to isolate the populations contained within the areas using a separate water source. The age-specific St. Louis County population proportions for the 1974 midpoint of the 1972–1976 period were then applied to each water-supplied group to obtain the appropriate age-specific denominators for calculating cancer death rates.

The cancer death certificates for all of St. Louis County for the period 1972–1976 were then obtained, and the place of residence was located within the demarcated geographic areas supplied by the several different water sources.

The sex-specific rates for all cancers and for grouped, specific cancers were determined for each population, for all ages, and in four specific age categories. Table 1 shows the sex-specific rates for all cancers for the specified age groups. It was somewhat surprising to find that the population served by St. Louis County–Meramec River water and the communities using well water had higher rather than lower mortality rates for all cancers in comparison to those served by St. Louis County Missouri River water. Similar higher rates were found for most of the group-specific cancer diagnoses among those using the Meramec River and well water when compared to those using Missouri River water.

It would appear therefore that no rate-lowering effect on cancer mortality is being exerted on the total St. Louis County mortality rates by the inclusion of that proportion of the county popuiation which is not using the Missouri River water as a drinking water source. Quite the opposite effect is found.

TABLE 1

Environmental health surveillance center data on 1972-1976 deaths and average annual death rates per million population of St. Louis County residents by water source

Source	Sex	All Cancer Death Rates					All Cancer Deaths				
		Age					Age				
		< 15	15–44	45–64	> 65	Total	< 15	15–44	45–64	> 65	Total
Missouri River	male	43	189	3233	13 778	1730	22	155	1180	1785	3142
	female	47	257	2866	7526	1497	23	226	1130	1570	2949
	total	45	224	3042	9921	1609	45	381	2310	3355	6091
Meramec River	male	44	245	3930	13 372	1867	5	45	322	388	780
	female	37	278	3044	8798	1462	4	53	280	307	624
	total	41	262	3379	9867	1660	9	98	582	695	1384
Nonriver	male	77	191	4229	18 867	2305	2	6	79	125	214
	female	38	430	2540	10 512	1823	1	20	53	116	190
	total	58	317	3338	13 648	2049	3	28	132	241	404

TABLE 2

*All cancer deaths in 1972–1976 in nonmetropolitan areas served by open water treatment plants exposed and not exposed to smokestack effluent**

	Male Age 45–64†		Female Age 45–64‡		Male Over Age 65†		Female Over Age 65†*	
	Smoke Exposure	No Smoke Exposure	Smoke Exposure	No Smoke Exposure	Smoke Exposure	No Smoke Exposure	Smoke Exposure	No Smoke Exposure
With cancer	395	1181	338	1048	868	2780	772	2499
Without cancer	23 862	73 066	27 155	80 346	12 736	38 837	19 321	55 497

*Nonmetropolitan areas exclude St. Louis city, St. Louis county, and Kansas City.
†$X^2 = 0.4867$; $P = 0.4845$; relative risk (smoke exposure/no smoke exposure), $RR = 1.041$
‡$X^2 = 0.5531$; $P = 0.4571$; relative risk (smoke exposure/no smoke exposure), $RR = 0.955$
§$X^2 = 0.2284$; $P = 0.6327$; relative risk (smoke exposure/no smoke exposure), $RR = 0.982$
**$X^2 = 8.0929$; $P = 0.0044$; relative risk (smoke exposure/no smoke exposure), $RR = 0.892$

The lower cancer mortality rate among the St. Louis County population, 80 percent of whom were using Missouri River water, in comparison to the much higher rates among the St. Louis city population, all of whom were using Missouri River water, cannot be explained on the basis of different water sources.

Effect of differing water treatment and storage methods. The possibility remains that differences in the water treatment methods or the exposure to the environment of the open treatment plants or raw waters stored in reservoirs are causing a possible increased carcinogenic effect to be exerted by the St. Louis city water.

The smaller of the two St. Louis city water plants, Howard Bend, which has about one third the capacity of the larger Chain of Rocks plant, had a coal-burning power plant adjacent to the open treatment plant until 1971 when the power plant was closed. If this past exposure of the smaller open water treatment plant had a carcinogen-inducing effect on the St. Louis city water, this was not identifiable as a "within city" variable, since the water from both plants is intermittently mixed prior to its distribution. Any such effect would, in addition, probably be inseparable from that caused by local air pollution, which could have exerted its own direct effect on cancer mortality.

A statewide grouping of open water treatment plants exposed to adjacent coal-fired power plants, excluding St. Louis and other metropolitan areas, was compared to a similar open water treatment plant grouping that was not so exposed (Table 2). No apparent increased carcinogenic effect was reflected, at least in the cancer mortality rates, in the populations using the open treatment plant water exposed to smoke. It is therefore very unlikely that the increased cancer mortality rates in the city of St. Louis can be attributed to the exposure of the smallest of its two open water treatment plants to coal smoke from a power plant closed since 1971.

The second possible difference between St. Louis city and county drinking waters, despite their common source, might involve significant differences in the water treatment processes used in the two communities during the past two to three decades.

Field visits to the water supply plants revealed that the privately owned St. Louis County Water Company and the St. Louis city municipal water plants, both using the Missouri River source, had employed very similar treatment methods until 1955. At that time the St. Louis County Water Company changed the sequencing of the addition of ammonia from the sedimentation basins (prefiltration) to the distribution point (postfiltration). Chloramines were thus produced only at the start of distribution. In addition, the amount of chlorine applied was doubled at that time from 3 to 6 kg/ML (25 to 50 lb/mil gal) to achieve breakpoint level.

By contrast the St. Louis city plant has continued its original practice of adding chlorine immediately, and about 4 hr later adding the ammonia in the sedimentation basin. Thus chloramine is carried throughout the St. Louis city plant rather than only in the distribution system as in the St. Louis county plant.

As a result trihalomethanes produced by chlorine in the St. Louis county plant may have increased somewhat since 1955. If this were an important factor in producing higher rates of cancer mortality, one might expect that the cancer death rates in St. Louis County would be increasing in recent years, when compared to the city of St. Louis which maintained lower chlorine levels and the practice of introducing ammonia early in its water treatment process throughout the years since 1955. Such trend analysis will be undertaken, but the city cancer death rates continue to be significantly higher than those of St. Louis County.

Analyses have been conducted of the St. Louis city and county waters using the Pelon method of Ames testing on the unconcentrated finished water and on lyophilized 19-L (5-gal) samples. These tests have shown no mutagenesis. Chemical analyses averaged over the past decade have shown no significant differences between the two finished waters.

The dependent variable: cancer mortality rates

Race, sex, and age variables. The factors affecting drinking water having been considered and weighed to the greatest extent possible, a number of confounding effects remain that could act on the dependent variable, the cancer mortality rates. Such effects could relate to age,

TABLE 3A

Total cancer deaths and annual average rates per million for 1960–1972 for all cancers in St. Louis and St. Louis County by age groups from under 5 years to 44 years

Area	Total		Age									
			< 5		5–14		15–24		25–34		35–44	
	Rates	Deaths	Rates	Deaths	Rate	Deaths	Rate	Deaths	Rate	Deaths	Rate	Deaths
St. Louis												
white												
male	3301	8438	76	17	52	21	120	44	185	56	656	175
female	2366	7180	61	13	62	32	73	32	263	77	806	246
total	2793	15 618	69	30	67	53	95	76	224	133	736	421
nonwhite												
male	3144	3097	79	15	49	16	132	30	221	35	1099	184
female	1458	2434	53	10	70	26	66	18	324	87	1262	249
total	1778	5531	66	25	60	44	96	48	279	102	1192	413
all races												
male	2874	11 535	77	32	51	39	124	74	196	91	813	339
female	2038	9614	57	23	78	58	70	50	287	144	963	495
total	2423	21 149	67	55	65	97	95	124	244	235	906	834
St. Louis County												
white												
male	1492	7098	103	53	72	84	136	98	168	114	511	359
female	1307	7184	79	39	85	62	60	49	139	102	692	506
total	1397	14 862	91	92	84	146	96	147	153	216	603	865
nonwhite												
male	1483	329	35	1	66	4	58	2	204	6	676	17
female	972	235	73	2	16	1	25	1	58	2	781	22
total	1217	564	54	3	41	5	41	3	123	8	732	39
all races												
male	1488	8027	99	54	72	88	132	100	169	120	515	376
female	1290	7399	78	41	53	63	59	50	135	104	693	528
total	1386	15 426	89	95	63	151	93	150	151	224	606	904

sex, racial, socioeconomic, educational, or occupational differences between the populations of the two areas, or to other environmental factors such as air pollution to which these populations may be differentially exposed.

Table 3 shows the total annual cancer deaths and death rates for cancer for both the city and the county, averaged for the 1960–1972 period by ten-year age groups, by sex, and by race. The nonwhite group in Missouri represents the black population, primarily.

The total all ages and all cancer rates in St. Louis are almost twice those of St. Louis County. The same is true for the all ages cancer rates for each sex when the white cancer death rates for the city are compared with the white St. Louis County rates. Similarly, comparing the nonwhite death rates for all cancers reveals a somewhat less marked difference, but significantly higher rates are still evident among the nonwhite population in the city than in the county. The numbers of nonwhite deaths in St. Louis County, however, are quite small.

In terms of all ages and all cancer death rates, the St. Louis city rates remain significantly higher than those of the county, whether the comparison is between the combined races or each racial group separately or the combined sexes or each sex separately. The higher death rates for all ages and all cancers in the city do not appear to be altered or confounded by either sex or race differences in the two populations.

The ten-year age group comparisons require separate consideration. Within the age groups 0–5, 5–14, and 15–24 years, in which death resulting from cancer is a relatively rare occurrence, the St. Louis County cancer death rates are as high as and sometimes higher than those for St. Louis, particularly among the males of both racial groups. However the number of deaths is too small for their significance to be determined.

The significantly higher cancer death rates for the city of St. Louis begin in the 25–34 age group and reach their maximum peaks of differences in the middle age groups (35–54) in both sexes and in both white and nonwhite races. The rates in this age group are significantly higher for the city. The higher city rates also begin at an earlier age for the females (25–34) of both racial groups, but the male differences become much greater than the female differences within the age groups 35 through 64 years. The cancer death rate differences between St. Louis city and county also remain very high among the males after age 65, but the difference is less marked than that within the male 35–64 age group in both racial groups. Female rates, on the other hand, become almost equivalent in the city and county for age groups above age 55 in all races.

It is apparent from the foregoing data that race, sex, and age over 35 do not alter the fact that the city mortality rate for all cancers is significantly higher than the county rate.

On examination of a grouping of specific cancer types as shown in Table 4 for the age groups 35–44, 45–54, 55–64, and 65–74, it appears that the city cancer death rates remain consistently much higher than those in St. Louis County for the years 1960–1972. The unspecified cancer mortality type was included to examine the possibility of less accurate cancer diagnoses in either the city or the county. The differences between the city and county unspecified groups are actually considerably less than those between the other groups, which helps to eliminate any major effect of differences in diagnostic death certification in the two areas.

An interesting finding that will be simply noted here was the fact that the nonwhite death rates for digestive cancer were consistently higher for both sexes and all ages over age 35. Respiratory cancer occurs at higher rates among the nonwhite males up to age 55 and in the nonwhite females up to age 65. These statistics will require further exploration, but are not immediately relevant to water supply and cancer relationships.

This analysis of the possible relationship of public drinking water and cancer death rate differences between the city and county of St. Louis provides no firm evidence to support the hypothesis that drinking water is a significant factor contributing to the marked cancer death rate differences between the two communities.

Socioeconomic variables. By contrast, a number of independent or interacting variables could serve to distinguish the two communities through either a direct or inverse correlation with the cancer death rates. These possibilities are mentioned to counter the criticism that cancer mortality is too blunt a tool for use in dissecting for environmental differences between two such populations.

TABLE 3B

Total cancer deaths and average annual rates per million for 1960–1972 for all cancers in St. Louis and St. Louis County by age groups from 45 years to over 85 years

Area	Age									
	45–54		55–64		65–74		75–84		85+	
	Rate	Deaths	Rate	Deaths	Rate	Deaths	Rate	Deaths	Rate	Deaths
St. Louis										
white										
male	2480	790	6600	2170	12 272	2837	18 821	1937	20 793	391
female	2073	805	3553	1496	5877	2078	9353	1816	12 807	584
total	2257	1595	4899	3666	8405	4915	12 633	3753	15 139	975
nonwhite										
male	3820	533	8039	913	12 159	903	15 565	407	12 296	78
female	3012	514	4787	648	6286	563	7513	261	8137	76
total	3375	1047	6271	1561	8932	1466	10 971	668	9820	154
all races										
male	2682	1323	6958	3083	12 217	3740	17 966	2344	18 468	469
female	2356	1319	3848	2144	5946	2841	9046	2077	11 972	660
total	2503	2642	5226	5227	8505	6581	12 278	4421	14 021	1129
St. Louis County										
white										
male	1582	992	4824	2109	10 054	2236	16 269	1343	18 376	310
female	1737	1139	3427	1815	5817	1747	9884	1437	12 850	488
total	1661	2131	4100	3724	7820	3983	12 196	2780	14 600	778
nonwhite										
male	2874	55	6531	90	11 574	93	12 403	43	19 767	17
female	1743	37	4437	68	6011	59	8540	35	7400	8
total	2279	92	5428	158	8815	152	10 333	78	12 966	25
all races										
male	1598	1047	4869	2199	10 091	2329	16 055	1386	18 198	327
female	1734	1176	3456	1883	5816	1806	9832	1472	12 679	478
total	1667	2223	4136	3882	7839	4135	12 108	2858	14 485	803

St. Louis and St. Louis County reveal a strong and direct cancer death rate correlation when one examines for the percentage of the 1970 population with incomes below the poverty level.[14] In St. Louis 14.3 percent of families had incomes below the poverty level, compared to only 3.8 percent in St. Louis County. This was also true (25.5 vs 15.4 percent) among nonwhite families.

A similar but inverse correlation was found between cancer death rates and the 1970 median and mean income. The city total population median income was $8182 with a mean of $9268; St. Louis County median income was $12 392 with a mean of $14 533.

An inverse correlation was determined between education level and cancer death rates. The median number of school years completed by city residents was 9.6 years, while the county median was 12.3 years.

The occupational patterns in the two areas showed no significant differences in the percentage of the total working population engaged in manufacturing: 27.8 percent in the city and 27.6 percent in the county. In addition, when carcinogen-producing industries such as primary metal manufacturing, metal fabricating, chemicals, and printing are grouped together, city statistics showed that 27.8 percent of the workers engaged in manufacturing were engaged in these four industries, while in St. Louis County 27.5 percent were employed in these same industries.

This relatively crude general industrial pattern does not appear to be sufficient to serve as a distinguishing variable for comparisons between the communities, in concurrence with the findings of De Rouen for the New Orleans area.[7]

One other difference in the 1970 census occupational characteristics was found to vary directly with the cancer death rates. This was the percentage of the work force classed as "laborers." In the city laborers numbered 5.6 percent; in the county, 2.9 percent. It would appear reasonable to assume that a greater percentage of this social class resides in the city than in the county. In addition, the presence of a larger unskilled labor group within the city would suggest greater potential for workplace exposure to carcinogens by virtue of the "dirtier" jobs held by unskilled labor in manufacturing when compared, for example, to skilled craftsmen or clerks.

Effect of air pollution. The final possible independent variable to be considered here is the air pollution in St. Louis and St. Louis County, using the EPA region 7 report of December 1978[13] regarding air pollution over greater St. Louis.

During the 1950s the air pollution in the city was sufficient to bring about the impending closure of the St. Louis Botanical Gardens. Action taken at that time and subsequently has permitted the gardens to be kept in the city location because of a reduction in air pollution. Nevertheless, the city of St. Louis still experienced continuing significantly higher average annual geometric mean levels for particulates and higher annual arithmetic mean levels for sulfur dioxide throughout the 1970–1977 period, when compared to St. Louis County. Thus air pollution as measured by total suspended particulates and sulfur dioxide also varies directly with the cancer mortality rates in the two areas. Even during the last decade the only air standard that has been consistently met, despite the gradual and continuing improvement in the greater St. Louis metropolitan area, is the nitrogen dioxide level which apparently was never a problem.

It would appear that a high degree of discriminatory power is shown by these latter descriptive variables, using only two-by-two tabulations, in distinguishing the city from the county by virtue of their differing cancer mortality rates. On the other hand, the drinking water supplies drawn from the same source at almost the same point show no such discriminatory variations and should therefore probably not be used to explain the differences in cancer death rates. This is somewhat in disagreement with the conclusions reached in the New Orleans water supply study.

Conclusions

1. The age, sex, and race-specific death rates for all cancers as well as the death rates for specific cancer types are significantly higher in the city of St. Louis than in adjacent St. Louis County for the 1960–1976 period.

2. No significant differences are evident in their common Missouri River water source, nor in the general water treatment processes used by the city and the county. No differences exist in finished water mutagenicity as measured by the Ames test using both the Pelon and lyophilization methods. Nor were

TABLE 4

Average annual death rates per million for 1960–1972 for grouped cancer types and all cancers in St. Louis and St. Louis County

Cancer Type	Age	White Rates						Nonwhite Rates						Total Rates All Races					
		Male		Female		Total		Male		Female		Total		Male		Female		Total	
		City	County	City	County	City	County	City	County	City	County	City	County	City	County	City	County	City	County
Buccal	35–44	11	12	6	0	8	7	87	79	20	0	49	37	38	15	11	2	23	8
	45–54	150	51	43	24	91	37	250	104	70	0	151	49	180	53	51	23	109	38
	55–64	444	160	59	46	228	101	290	145	66	0	168	68	403	159	81	45	212	100
	65–74	467	309	98	73	160	244	363	497	44	0	188	224	441	285	87	70	231	162
	All ages	148	44	32	14	85	29	89	49	20	4	52	25	126	45	28	14	73	29
Digestive	35–44	131	104	114	123	122	113	288	119	218	177	248	150	187	104	154	124	169	114
	45–54	583	412	365	318	464	365	1297	731	755	188	999	446	799	421	484	314	626	366
	55–64	1736	1365	891	885	1259	1119	2976	2249	1381	1044	2109	1614	2051	1390	1005	895	1466	1133
	65–74	3681	3075	2132	1908	2744	2450	4726	4729	2414	1528	3460	2969	3928	3128	2186	1971	2890	2464
	All ages	987	434	746	389	852	411	756	518	449	223	591	364	895	436	639	381	757	406
Respiratory	35–44	270	151	55	41	155	94	388	159	136	71	245	112	311	150	87	42	189	95
	45–54	1051	584	172	198	568	388	1376	1306	289	329	787	792	1148	604	201	202	628	399
	55–64	2816	1875	325	284	1416	1050	2568	2394	524	522	1466	1406	2753	1888	371	291	1426	1060
	65–74	4438	3341	436	452	2019	1681	2558	2384	389	815	3170	1512	3972	3301	427	463	1874	1673
	All ages	1109	460	167	99	598	274	566	401	122	111	310	250	910	456	151	99	500	272
Breast and genito-urinary	35–44	41	31	472	372	271	205	73	39	715	426	438	244	52	31	566	373	339	206
	45–54	163	108	1156	890	708	506	186	309	1441	989	877	619	169	111	1241	892	758	509
	55–64	562	425	1819	1670	1156	1019	680	1233	1994	2088	1486	1683	643	449	1708	1585	1236	1038
	65–74	1812	1573	2192	2184	2042	1924	2518	1991	2247	2852	2370	2404	1979	1585	2199	2203	2109	1939
	All ages	805	209	962	532	753	375	337	248	605	484	480	371	443	210	833	529	654	374
Unspecified	35–44	82	102	78	72	80	87	154	159	298	94	109	75	107	104	77	69	91	86
	45–54	323	219	182	189	248	203	430	313	531	391	357	198	355	221	218	185	279	203
	55–64	587	578	363	369	461	469	827	362	745	509	666	377	647	569	403	389	511	465
	65–74	1051	926	514	562	728	717	1238	1244	748	976	908	840	1094	935	580	560	778	720
	All ages	298	176	205	142	268	158	232	138	156	78	192	105	273	174	212	138	240	155
Blood and lymph	35–44	105	108	65	73	90	84	100	79	91	106	95	93	103	107	75	74	88	90
	45–54	194	176	123	109	155	142	207	209	146	141	174	173	198	177	130	110	161	143
	55–64	438	400	287	248	353	321	431	145	273	328	345	240	435	391	283	250	350	318
	65–74	752	818	480	532	588	654	686	822	356	305	505	448	735	810	454	525	569	647
	All ages	243	159	197	120	218	139	144	117	92	66	116	90	207	157	159	118	181	137
All cancers	35–44	650	511	806	692	736	603	1099	676	1262	781	1192	732	813	515	983	693	906	606
	45–54	2480	1562	2073	1737	2257	1651	3820	2874	3012	1743	3375	2279	2882	1598	2356	1734	2593	1667
	55–64	6600	4824	3533	3427	4889	4100	6039	6531	4787	4437	6271	5428	6958	4869	3848	3456	5226	4136
	65–74	12 272	10 054	5877	5817	84 051	76 201	12 159	11 574	6265	6011	8932	8515	12 217	10 091	5946	5810	8505	7639
	All ages	3301	1492	2366	1307	2793	1397	2144	1483	1458	972	1776	1217	2874	1488	2038	1290	2423	1386

past differences found in inorganic chemical analyses of the two waters.

3. The 20 percent of the population in St. Louis County that draws on the presumably less polluted Meramec River instead of the Missouri River for their water showed for the 1972–1976 period a generally higher cancer death rate than those using Missouri River water.

4. The authors find no evidence to support an association of the marked differences in cancer death rates with the public drinking waters of St. Louis and St. Louis County.

5. A number of other variables do show what appear to be significant associations with the cancer death rate differences between the city and county. Among these are median income (inverse correlation), percent of the population with incomes below the poverty level (direct correlation), school years completed (inverse correlation), percentage of workers who are classed as unskilled laborers (direct correlation), and air pollution as measured by total suspended particulates and sulfur dioxide (direct correlation).

6. The public drinking water supply does not appear to be a significant factor in producing higher cancer death rates in the city than in St. Louis County.

Acknowledgments

This research was supported by EPA grant R805297. Appreciation is expressed for the cooperation of the St. Louis municipal and county water companies in the conduct of this study.

References

1. Dorn, H.F. & Cutler, S.J. Morbidity From Cancer in the United States. PHS Monograph 56 (1959).
2. Mason, T.J. & McKay, F.W. US Cancer Mortality by County, 1950–69. DHEW Publ. 74-615. NCI (1974).
3. Harris, R.H. The Implications of Cancer-Causing Substances in Mississippi River Water. Environmental Defense Fund, Washington, D.C. (1974).
4. Page, T.; Harris, R.H.; & Epstein, S.S. Drinking Water and Cancer Mortality in Louisiana. *Sci.*, 193:55 (1976).
5. Industrial Pollution of the Lower Mississippi River in Louisiana. USEPA, Region VI, Dallas (1972).
6. Preliminary Assessment of Suspected Carcinogens in Drinking Water: Report to Congress. USEPA, (Dec. 1975).
7. De Rouen, T.A. & Diem, J.E. Relationships Between Cancer Mortality in Louisiana Drinking Water Source and Other Possible Causative Agents: Origins of Human Cancer. Cold Spring Harbor Laboratory (1977).
8. Buncher, C.R.; Kuzma, R.J.; & Forcade, C.M. Drinking Water as an Epidemiologic Risk Factor for Cancer. Origins of Human Cancer. Cold Spring Harbor Laboratory (1977).
9. Census of Public Water Supplies in Missouri. Publ. E 2.48. Missouri Dept. of Natural Resources. (1973).
10. Municipal Water Facilities for Communities of 25 000 Population and Over in US and Possessions, Jan. 1, 1964. DHEW PHS Publ. 661 (1964).
11. Miller, R.W.; Meinhardt, T.; & Marienfeld, C.J. River Water and Cancer Mortality. Dept. of Natural Resources State Rept., Missouri Environment (1977).
12. Water Resources in St. Louis Area, Mo. Water Resources Rept. 30. Rolla, Mo. (1974).
13. Air Pollution Over Greater St. Louis. 907/9-78-003. USEPA Region VII (Dec. 1978).
14. General Social and Economic Characteristics of Missouri: 1970 Census of Population. PC(1)-C27, Missouri.

A paper contributed to and selected by the JOURNAL, authored by Carl J. Marienfeld, prof. family and community medicine and dir. envir. health surveillance program, Michael D. Collins (Student Member, AWWA), res. assoc., Harley T. Wright, asst. prof., Ravula Reddy, res. assoc., Gary Shoop, res. asst., Kay K. Roberts, res. asst., and Philip Rust, asst. prof., all of the Univ. of Missouri, Columbia, Mo.

22199 (St. Louis, Mo.) 4110